

Occupational Risk Factors and Prostate Cancer in U.S. Blacks and Whites

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Although prostate cancer is a major disease, causal factors are only partially understood. We examined occupational risk factors for this disease in a large case control study among U.S. blacks and whites. The study included 981 new pathologically confirmed prostate cancer cases (479 blacks and 502 whites) diagnosed between 1986 and 1989, and 1,315 population controls (594 blacks and 721 whites) who resided in Atlanta, Detroit, and 10 counties in New Jersey, covered by population-based cancer registries. Information on occupation, including a lifetime work history, was collected by in-person interview. No clear patterns of risk were found for U.S. whites versus blacks, nor for white-collar versus blue-collar jobs. Farming was related to prostate cancer (OR = 2.17; 95% CI = 1.18–3.98). Risk was restricted, however, to short-term workers and workers in crop production. Risk was not limited to those farming after 1950, when widespread use of pesticides started. Risks increased with increasing years of employment in firefighting (χ^2_{trend} $p = 0.02$) and power plant operations (χ^2_{trend} $p = 0.03$), and were elevated among long-term railroad line-haulers (OR = 5.85; 95% CI = 1.25–27.4); jobs with potential polycyclic aromatic hydrocarbon (PAH) exposures. Risk was elevated among athletes (OR = 5.38; 95% CI = 1.48–19.6). However, most of the cases were athletes before 1960, so the potential use of anabolic steroids was excluded. Although some clues about potential occupational associations were found, the overall results show that occupation is not a major determinant of prostate cancer risk. Am. J. Ind. Med. 34:421–430, 1998. © 1998 Wiley-Liss, Inc.

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INTRODUCTION

Prostate cancer is the most commonly diagnosed cancer among men in the United States, accounting for about 25% of all cancer cases, and is the second most common cause of cancer death. Blacks in the United States have the highest mortality rate from this cancer [Ross and Schottenfeld, 1996].

The causes of prostate cancer are not well understood. Genetic and hormonal factors probably play an important role, in combination with dietary and other lifestyle factors [Ross and Schottenfeld, 1996]. The role of occupational factors in the etiology of prostate cancer is unclear. Epidemiological studies have reported excess risks of prostate cancer among farmers, metal workers, mechanics and repairmen, chemical, rubber and nuclear industry workers, and among workers exposed to cadmium and PAHs; however, results

have often been contradictory [Nomura and Kolonel, 1991; van der Gulden et al., 1992, 1996, 1997; Morrison et al., 1993; Aronson et al., 1996; Ewings et al., 1996; Ross and Schottenfeld, 1996; Keller-Byrne et al., 1997; Whorton et al., 1998].

We examined occupational risk factors for prostate cancer by a two-tiered approach. First, an occupational mortality survey was carried out based on death certificate reports from 24 states, from 1984 to 1993 [Krstev et al., 1998]. That study was very large but was limited because only occupational data from death certificates were available. Here, we evaluate complete work histories for 981 incident prostate cancer cases and 1,315 population-based controls. As U.S. blacks and whites tend to have different occupational patterns, this study was designed to determine if the racial differential in work patterns could contribute to the difference between these groups in prostate cancer risk.

MATERIALS AND METHODS

A large population-based case control study of four cancer sites among blacks and whites (i.e., multiple myeloma and cancers of the esophagus, pancreas, and prostate) was conducted during 1986–1989 in three areas of the U.S. All newly diagnosed cases of prostate cancer among black and white men, aged 40–79, who resided in one of three areas covered by population-based cancer registries—the Georgia Center for Cancer Statistics (De Kalb and Fulton counties), the Metropolitan Detroit Cancer Surveillance System (Wayne, Oakland, and Macomb counties), and the New Jersey State Cancer registry (10 New Jersey counties)—were identified for the study [Hayes et al., 1993]. Subjects with histologically confirmed prostate cancer were identified from pathology and outpatient records at hospitals covered by these registries, between 1 August 1986 and 30 April 1989. To ensure a broad distribution by site, age, and race, a varying proportion of cases was selected by random sampling for inclusion in the study from among the total number of cases identified in each age-race group.

One general-population control group was selected for all four cancer types under investigation in the three geographic areas, proportional to the expected age, sex, and race distribution of the cases. Control subjects younger than 65 were selected at periodic intervals through a random-digit dialing (RDD) sampling procedure. Older controls were systematically selected by random sampling from computerized records of the Health Care Financing Administration, stratified by age (65–69, 70–74, 75–79) and race (blacks, whites) for each geographic area. In total, 981 cases and 1,315 controls were available for analysis. Subjects were excluded from selected analyses if they did not provide information about usual occupation (2 cases, 7 controls) or usual industry (4 cases, 10 controls).

After obtaining informed consent, cases and controls were interviewed in person by a trained interviewer, usually in the home setting. The questionnaire was designed to obtain detailed information on potential risk factors for the four cancer sites. Information on usual occupation and industry was collected, as well as a detailed work history, including all jobs held for 6 months or more since the age of 16. Usual activities or duties in each job and the kind of business and industry were also recorded. Job titles and industries were subsequently coded according to the Standard Occupational Classification (SOC) [U.S. Department of Commerce, 1980] and Standard Industrial Classification (SIC) [Executive Office of the President, 1972].

Odds ratios (ORs) and 95 percent confidence intervals (CI) for prostate cancer were estimated by unconditional logistic regression analysis [Breslow and Day, 1980]. The odds ratios were calculated, adjusted for age (< 60, 60–69, 70 or more years), study site (Atlanta, Detroit, or New Jersey), and, as appropriate, for race (black and white). Prostate cancer risk was assessed with respect to usual and ever employment in occupation and industry groups (all two-digit, three-digit, and four-digit SOC-80 and SIC-72 codes) compared to a referent of study subjects who were never employed in that type of job. In addition, selected analyses were carried out by duration of employment (never [referent], <5, 5–19, and 20 or more years), for occupations and industries in which the overall ORs were significantly increased or decreased, and for all ORs that were greater than 2.5. To test for trend (χ^2_{trend}), employment duration was treated as continuous in the regression model by entering the median value for each duration category among the controls.

RESULTS

Occupation

Based on broad (two-digit SOC-80 codes) occupational categories for ever having held a job (Table I), prostate cancer cases tended to be overrepresented in service occupations (OR = 1.43) among blacks (OR = 1.42) and whites (OR = 1.41), and as administrators and managers (OR = 1.36) among whites. In addition, significant excesses were shown for plant and system operators (OR = 2.12), particularly among blacks (OR = 4.06), and among “other laborers” (OR = 1.26), again largely for blacks (OR = 1.37). When broad groups of usual occupations were analyzed (data not presented) significantly elevated risks were also found in service occupations (OR = 1.51; 95% CI = 1.11–2.05), particularly among whites (OR = 1.76; 95% CI = 1.08–2.86).

When detailed analyses were carried out for ever employment in specific occupational groups (Table II), a large number of significant associations were identified,

TABLE I. Risk (ORs) for Prostate Cancer by Occupation (Broad Two-Digit Occupational Groups) in Atlanta, Georgia, Detroit, Michigan, and New Jersey, 1986–1989^a

Occupation (SOC)	Total		Blacks		Whites	
	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)
Administrative and managerial (11–14)	156/203	1.17 (0.92–1.49)	24/43	0.72 (0.43–1.21)	132/160	1.36 (1.03–1.79)
Engineers, surveyors, and architects (16)	40/59	1.00 (0.66–1.53)	4/6	0.84 (0.23–3.07)	36/53	1.02 (0.65–1.59)
Natural scientists and mathematicians (17–18)	14/35	0.60 (0.32–1.14)	0/4		14/31	0.69 (0.36–1.33)
Social scientists, social and religious workers, and lawyers (19–21)	29/39	1.11 (0.68–1.82)	13/11	1.64 (0.72–3.77)	16/28	0.88 (0.47–1.67)
Teachers, librarians, counselors (22–25)	50/75	0.99 (0.68–1.45)	15/22	0.91 (0.46–1.79)	35/53	1.03 (0.65–1.62)
Health diagnosing and treating (26–28)	6/10	0.82 (0.29–2.30)	1/3	0.31 (0.03–3.00)	5/7	1.07 (0.33–3.45)
Registered auxiliary health work (29–30)	5/2	2.93 (0.56–15.2)	3/1	3.00 (0.31–29.2)	2/1	2.86 (0.25–32.3)
Writers, artists, and athletes (32–34)	43/49	1.29 (0.84–1.97)	15/14	1.39 (0.66–2.96)	28/35	1.18 (0.70–2.00)
Health technicians (36)	6/12	0.77 (0.28–2.08)	3/3	1.39 (0.27–7.06)	3/9	0.62 (0.16–2.34)
Other technicians (37–39)	68/91	1.11 (0.79–1.55)	15/18	1.07 (0.52–2.17)	53/73	1.20 (0.81–1.75)
Marketing and sales (40–44)	225/289	1.12 (0.91–1.38)	63/69	1.19 (0.82–1.72)	162/220	1.10 (0.85–1.41)
Administrative support (45–47)	275/363	1.07 (0.88–1.29)	109/133	1.03 (0.77–1.38)	166/230	1.09 (0.85–1.40)
Service occupations (50–52)	367/383	1.43 (1.19–1.71)	232/234	1.42 (1.11–1.82)	135/149	1.41 (1.07–1.85)
Agricultural, forestry, and fishing (55–58)	179/217	1.03 (0.82–1.29)	128/146	1.09 (0.82–1.44)	51/71	0.98 (0.66–1.44)
Mechanics and repairers (60–61)	181/225	1.12 (0.90–1.40)	67/91	0.91 (0.64–1.28)	114/134	1.30 (0.98–1.73)
Construction and extraction (63–65)	162/182	1.22 (0.97–1.54)	87/94	1.17 (0.84–1.62)	75/88	1.27 (0.91–1.78)
Precision production (67–68)	116/145	1.08 (0.83–1.41)	32/56	0.66 (0.42–1.05)	84/89	1.36 (0.98–1.89)
Plant and system operators (69)	21/13	2.12 (1.05–4.27)	12/4	4.06 (1.28–12.8)	9/9	1.46 (0.57–3.74)
Production occupations (71–78)	411/518	1.02 (0.85–1.21)	236/300	0.95 (0.74–1.23)	175/218	1.13 (0.88–1.46)
Transportation (81–83)	285/373	0.98 (0.81–1.18)	179/235	0.89 (0.70–1.15)	106/138	1.11 (0.83–1.48)
Other laborers (85–87)	371/426	1.26 (1.05–1.51)	239/247	1.37 (1.07–1.76)	132/179	1.14 (0.87–1.49)
Military (91)	134/164	1.12 (0.87–1.44)	59/58	1.29 (0.87–1.90)	75/106	1.04 (0.75–1.45)

^aOdds ratios that exclude 1.0 are noted in bold typeface.

including surveying and mapping technicians (OR = 8.33), athletes (OR = 5.38), grader, dozer, and scraper operators (OR = 3.96), supervisors in cleaning and building occupations (OR = 3.83), sales engineers (OR = 3.53), firefighters (OR = 3.34), packing and filling machine operators (OR = 3.30), extractive occupations (OR = 3.07), power plant operators (OR = 2.28), supervisors in food and beverage preparation (OR = 2.18), general farmers (OR = 2.17), and brick masonry workers (OR = 2.01). A decreased risk was found, however, for livestock workers (OR = 0.37).

Among blacks, supervisors in cleaning and building service, power plant operators, barbers, brick masonry workers, and workers in personal services had significantly elevated odds ratios. Among whites, odds ratios were elevated for electronic repairers, workers in business service, firefighters, sales engineers, general farmers, and supervisors in food and beverage preparation. Risks for farmers and forestry workers were examined with respect to employment before or after 1950, when pesticide use

became more common, but no pattern was found. For usual occupation, analyses at a more detailed level (data not presented) showed significantly increased risks for service occupations (except private household and protective) (OR = 1.46; 95% CI = 1.02–2.08), barbers (OR = 9.55; 95% CI = 1.19–76.9), particularly among blacks (OR = infinity), and brick masonry workers (OR = 3.63; 95% CI = 1.12–11.7) among both blacks and whites, while secondary school teachers had a significantly decreased risk for prostate cancer (OR = 0.35; 95% CI = 0.13–0.93).

Duration of Employment in Occupations

Risk for prostate cancer was significantly elevated among long-term workers (20 years or more) in protective services (OR = 1.90), firefighting and fire prevention (OR = 5.5), and among brick mason, stonemason, or tile setters and their helpers (OR = 3.89) (Table III). Only a few occupa-

TABLE II. Statistically Significant Associations^a of Occupations With Prostate Cancer^b

Occupation (SOC)	Total		Blacks		Whites	
	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)
Officials and administrators, other (12)	89/100	1.45 (1.06–1.98)	11/16	0.98 (0.45–2.18)	78/84	1.54 (1.09–2.17)
Athletes and related workers (34)	11/3	5.38 (1.48–19.60)	5/1	6.33 (0.72–55.40)	6/2	3.73 (0.73–19.10)
Surveying and mapping technicians (373)	6/1	8.33 (0.99–70.10)			5/0	
Supervisors; marketing and sales occupations (40)	79/67	1.67 (1.18–2.35)	17/16	1.31 (0.65–2.65)	62/51	1.83 (1.23–2.74)
Supervisors; sales occupation retail (403)	61/50	1.69 (1.14–2.50)	14/11	1.60 (0.71–3.59)	47/39	1.74 (1.11–2.72)
Business service sales (415)	12/9	1.99 (0.82–4.78)			11/6	2.84 (1.03–7.85)
Business service, except advertising, sales (4152)	8/5	2.30 (0.74–7.12)			7/2	5.15 (1.05–25.20)
Sales engineers (421)	12/5	3.53 (1.23–10.20)			11/5	3.28 (1.12–9.62)
Protective service (51)	84/83	1.47 (1.07–2.03)	36/35	1.32 (0.81–2.16)	48/48	1.57 (1.03–2.41)
Firefighting and fire prevention (512)	12/5	3.85 (1.34–11.10)	3/2	2.64 (0.43–16.20)	9/3	4.75 (1.26–18.00)
Firefighting (5123)	10/5	3.34 (1.13–9.91)	3/2	2.64 (0.43–16.20)	7/3	4.00 (1.01–1.86)
Service, except private household and protective (52)	314/326	1.38 (1.14–1.68)	215/219	1.38 (1.07–1.77)	99/107	1.37 (1.01–1.86)
Food and beverage preparation (521)	152/154	1.35 (1.05–1.73)	104/103	1.27 (0.93–1.73)	48/51	1.42 (0.93–2.16)
Supervisors; food and beverage preparation (5211)	27/17	2.18 (1.17–4.06)	13/8	2.02 (0.82–4.97)	14/9	2.46 (1.04–5.83)
Cleaning and building, except private household (524)	145/139	1.36 (1.04–1.76)	119/116	1.38 (1.03–1.86)	26/23	1.44 (0.80–2.59)
Supervisors; cleaning and building (5241)	11/4	3.83 (1.20–12.20)	9/3	4.15 (1.10–15.60)		
Janitors and cleaners (5244)	130/124	1.36 (1.03–1.79)	109/106	1.38 (1.02–1.88)	21/18	1.53 (0.79–2.93)
Personal service (525)	30/33	1.28 (0.77–2.12)	15/9	2.34 (1.00–5.45)	15/24	0.85 (0.44–1.65)
Barbers (5252)	12/7	2.06 (0.80–5.28)	9/3	3.87 (1.03–14.60)	3/4	0.80 (0.18–3.66)
Farm operators and managers (55)	48/36	1.63 (1.04–2.54)	30/23	1.59 (0.90–2.80)	18/13	1.90 (0.91–3.95)
General farmers (5512)	30/17	2.17 (1.18–3.98)	18/11	1.97 (0.91–4.25)	12/6	2.71 (1.00–7.38)
Livestock workers (5617)	6/21	0.37 (0.15–0.92)	4/11	0.48 (0.15–1.55)		
Mechanics and repairers (61)	175/210	1.18 (0.94–1.47)	63/87	0.90 (0.63–1.28)	112/123	1.42 (1.06–1.90)
Electrical and electronic repairers, commercial and industrial equipment (6153)	14/10	2.20 (0.97–5.03)			13/6	3.76 (1.40–10.10)
Electronic repairers, home entertainment equipment (6155)	8/4	3.71 (0.80–9.10)			7/2	5.22 (1.06–25.60)
Brickmasons, stonemasons, hard tile setters; helpers (641; 8641)	24/16	2.06 (1.08–3.92)	18/7	3.29 (1.34–8.06)	6/9	1.0 (0.35–2.86)
Extractive occupations, (656)	13/5	3.07 (1.08–8.68)	7/1	7.15 (0.87–58.80)	6/4	1.51 (0.51–6.69)
Plant and system operators (69)	21/13	2.12 (1.05–4.27)	12/4	4.06 (1.28–12.80)	9/9	1.46 (0.57–3.74)
Power plant operators (693)	16/9	2.28 (1.00–5.21)	9/3	3.96 (1.05–14.90)	7/6	1.68 (0.55–5.08)
Packing and filling machine operators (7662)	12/5	3.30 (1.14–9.52)	10/4	3.18 (0.97–10.40)		
Grader, dozer, and scraper operators (8317)	8/3	3.96 (1.03–15.10)	5/2	3.89 (0.73–20.70)	3/1	5.10 (0.51–50.80)
Handlers, equipment cleaners, and laborers (87)	348/386	1.30 (1.08–1.56)	230/228	1.45 (1.14–1.86)	118/158	1.13 (0.86–1.50)
Freight, stock, and material movers, hand (872)	182/195	1.31 (1.04–1.64)	114/114	1.29 (0.95–1.73)	68/81	1.33 (0.93–1.89)
Stock handlers and baggers (8724)	67/68	1.49 (1.05–2.12)	23/21	1.40 (0.76–2.59)	44/47	1.50 (0.97–2.32)
Miscellaneous manual occupations (876)	74/74	1.29 (0.92–1.79)	53/39	1.67 (1.08–2.59)	24/38	0.90 (0.53–1.54)

^aBased on three or more exposed cases.^bOdds ratios that exclude 1.0 are noted in bold typeface.

tions, however, showed a significant trend with increasing duration of employment: brick masonry workers ($\chi^2_{\text{trend}}, p = 0.01$), firefighters and related workers ($\chi^2_{\text{trend}}, p = 0.02$), power plant operators ($\chi^2_{\text{trend}}, p = 0.03$), and freight, stock, and material movers ($\chi^2_{\text{trend}}, p = 0.04$), particularly stock

handlers and baggers ($\chi^2_{\text{trend}}, p = 0.04$). A number of occupations showed elevated risks primarily among short-term workers: athletes and those in related occupations (e.g., athletic coach), supervisors in sales and food service occupations, janitors and cleaners, farm operators and managers,

TABLE III. Prostate Cancer Risk^a by Duration of Employment in Occupations^b

Occupation (SOC)	<5 years		5–19 years		≥20 years		Trend, <i>P</i>
	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	
Officials and administrators, other (12)	11/18	1.06 (0.49–2.28)	40/35	2.06 (1.28–3.33)	38/47	1.18 (0.75–1.85)	0.10
Athletes and related workers (34)	7/1	11.10 (1.35–91.8)	3/2	2.01 (0.33–12.3)	1/0		0.32
Supervisors; marketing and sales occupations (40)	25/20	1.82 (1.00–3.34)	27/23	1.73 (0.98–3.05)	27/24	1.48 (0.84–2.61)	0.05
Supervisors; sales occupations, retail (403)	24/14	2.47 (1.26–4.85)	21/20	1.51 (0.81–2.82)	16/16	1.26 (0.62–2.57)	0.24
Protective service occupations (51)	41/44	1.34 (0.86–2.08)	21/20	1.46 (0.78–2.73)	22/18	1.90 (1.00–3.59)	0.02
Firefighting and fire prevention occupations (512)	2/0		3/3	1.66 (0.33–8.37)	7/2	5.15 (1.05–25.20)	0.02
Firefighting occupations (5123)	2/0		3/3	1.66 (0.33–8.36)	5/2	3.94 (0.75–20.60)	0.07
Service occupations, except private household and protective (52)	154/160	1.45 (1.13–1.86)	95/102	1.28 (0.94–1.74)	65/63	1.42 (0.98–2.05)	0.05
Food and beverage preparation and service occupations (521)	90/96	1.31 (0.96–1.78)	38/35	1.42 (0.88–2.29)	24/22	1.49 (0.82–2.70)	0.09
Supervisors; food and beverage preparation and service occupations (5211)	10/4	3.60 (1.11–11.70)	10/7	1.77 (0.66–4.70)	7/6	1.75 (0.58–5.31)	0.12
Bartenders (5212)	4/1	5.40 (0.59–49.0)	5/3	2.00 (0.47–8.53)	3/2	1.85 (0.30–11.2)	0.28
Cleaning and building service occupations; except private household (524)	72/61	1.57 (1.10–2.26)	50/55	1.15 (0.77–1.73)	23/23	1.26 (0.70–2.29)	0.32
Janitors and cleaners (5244)	69/54	1.71 (1.17–2.49)	43/48	1.13 (0.73–1.75)	18/22	1.00 (0.53–1.90)	0.75
Farm operators and managers (55)	21/9	3.01 (1.36–6.66)	21/16	1.60 (0.83–3.11)	5/11	0.50 (0.17–1.46)	1.00
General farmers (5512)	12/5	3.02 (1.05–8.69)	13/7		4/5	0.90 (0.24–3.42)	0.33
Electrical and electronic repairers, commercial and industrial equipment (6153)	8/3	4.31 (1.12–16.6)	3/3	1.54 (0.30–7.75)	3/4	1.17 (0.26–5.31)	0.62
Brickmasons, stonemasons, hard tile setters; helpers (641, 8641)	8/7	1.65 (0.59–4.60)	4/5	1.12 (0.30–4.210)	12/4	3.89 (1.24–12.2)	0.01
Extractive occupations, NEC (656)	9/3	3.49 (0.94–13.0)	3/2	1.79 (0.29–10.90)	1/0		0.05
Sheet metal workers (6824)	6/1	6.68 (0.80–55.8)	3/1	3.89 (0.40–37.8)	1/3	0.51 (0.05–4.99)	0.82
Plant and system operators (69)	9/7	1.66 (0.61–4.52)	8/5	2.15 (0.69–6.66)	4/1	5.11 (0.56–46.6)	0.03
Power plant operators (693)	7/6	1.51 (0.50–4.55)	6/2	3.68 (0.74–18.40)	3/1	4.04 (0.41–39.8)	0.03
Metal fabricating machine operators and tenders (753)	3/3	1.33 (0.26–6.73)	2/0		3/1	3.60 (0.36–35.6)	0.22
Heating equipment operators and tenders (7544)	3/3	1.19 (0.24–5.97)	3/0		4/1	4.78 (0.52–43.5)	0.12
Packing and filling machine operators and tenders (7662)	4/2	2.77 (0.50–15.50)	7/2	5.02 (1.02–24.60)	1/1	1.12 (0.07–18.0)	0.17
Handlers, equipment cleaners and laborers (87)	203/216	1.39 (1.12–1.74)	112/121	1.29 (0.97–1.72)	32/48	0.90 (0.56–1.44)	0.96
Freight, stock, and material movers, hand (872)	110/130	1.23 (0.94–1.62)	55/52	1.39 (0.93–2.06)	16/12	1.70 (0.79–3.65)	0.04
Stock handlers and baggers (8724)	51/56	1.41 (0.95–2.09)	13/11	1.66 (0.73–3.77)	3/1	3.60 (0.37–34.9)	0.04

^aBased on five or more exposed cases.^bOdds ratios that exclude 1.0 are noted in bold typeface.

general farmers, electrical and electronic repairers, and handlers, equipment cleaners, and laborers.

Industry

Elevated risks were found for subjects ever employed in labor unions (OR = 6.21), variety stores (OR = 4.30),

drinking (OR = 2.34) and eating places (OR = 1.40), justice, public order and safety (OR = 1.66), railroads (OR = 1.61), and general farms, primarily with crops (OR = 1.42) (Table IV). Having ever held a job on a dairy farm and in the miscellaneous machinery industry, however, presented lowered odds ratios for prostate cancer. Among blacks, increased risks were found for those who worked in

TABLE IV. Statistically Significant Associations Between Industry and Prostate Cancer Risk^a

Industry (SIC)	Total		Blacks		Whites	
	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)
General farms, primarily crop (019)	107/95	1.42 (1.06–1.92)	77/63	1.57 (1.09–2.26)	30/32	1.25 (0.74–2.11)
Dairy farms (024)	3/13	0.28 (0.08–0.99)				
Building construction, general contractors (15)	97/110	1.20 (0.90–1.61)	68/58	1.57 (1.08–2.30)	29/52	0.79 (0.49–1.28)
General building contractors, residential (152)	48/44	1.43 (0.94–2.19)	34/23	1.85 (1.07–3.22)	14/21	0.92 (0.46–1.86)
General contractors, single-family houses (1521)	44/39	1.50 (0.96–2.35)	30/20	1.89 (1.05–3.41)	14/19	1.04 (0.51–2.12)
Bottled and canned soft drinks and carbonated waters (2086)	14/9	2.13 (0.91–4.99)	7/7	1.36 (0.47–3.99)	7/2	5.37 (1.09–26.50)
Paper mills, except building paper mills (262)	15/12	1.63 (0.75–3.52)	4/9	0.49 (0.15–1.63)	11/3	6.30 (1.73–23.00)
Transportation equipment (37)	324/376	1.17 (0.95–1.44)	161/203	1.08 (0.78–1.48)	163/173	1.37 (1.04–1.81)
Railroad transportation (40)	65/50	1.66 (1.13–2.44)	46/30	1.83 (1.13–2.98)	19/20	1.39 (0.73–2.67)
Railroads (401)	62/49	1.60 (1.08–2.37)	44/29	1.79 (1.09–2.93)	18/20	1.34 (0.69–2.58)
Railroads, line-haul operating (4011)	60/47	1.61 (1.08–2.40)	42/29	1.69 (1.03–2.79)	18/18	1.50 (0.77–2.96)
Trucking, local and long distance (421)	52/81	0.87 (0.61–1.26)	36/37	1.23 (0.76–2.00)	16/44	0.52 (0.29–0.94)
Building materials, hardware, garden supply, and mobile home dealers (52)	16/12	1.84 (0.86–3.93)	3/5	0.67 (0.16–2.85)	13/7	2.79 (1.09–7.15)
General merchandise stores (53)	56/53	1.51 (1.02–2.23)	21/19	1.46 (0.77–2.77)	35/34	1.51 (0.92–2.48)
Variety stores (533)	9/3	4.30 (1.15–16.0)	3/2	2.31 (0.37–14.20)	6/1	8.39 (1.00–70.50)
Furniture, home furnishings (57)	25/21	1.76 (0.97–3.18)	7/9	1.10 (0.40–3.00)	18/12	2.38 (1.12–5.04)
Eating and drinking places (581)	102/93	1.49 (1.11–2.01)	64/57	1.44 (0.98–2.11)	38/36	1.63 (1.01–2.63)
Eating places (5812)	84/82	1.40 (1.01–1.93)	56/49	1.47 (0.97–2.21)	28/33	1.36 (0.80–2.31)
Drinking places (5813)	22/12	2.34 (1.14–4.79)	11/9	1.59 (0.65–3.93)	11/3	4.51 (1.23–16.50)
Direct selling establishments (5963)	10/9	1.50 (0.60–3.74)			9/3	4.06 (1.08–15.30)
Banking (60)	18/32	0.79 (0.44–1.43)	9/3	3.44 (0.91–13.00)	9/29	0.45 (0.21–0.97)
Amusement and recreation services, except motion pictures (79)	51/52	1.42 (0.95–2.11)	30/18	2.30 (1.25–4.24)	21/34	0.87 (0.49–1.53)
Membership organizations (86)	39/30	1.87 (1.14–3.05)	15/12	1.56 (0.71–3.43)	24/18	2.14 (1.14–4.02)
Labor unions (863)	9/2	6.21 (1.32–29.10)			7/0	
Justice, public order and safety (92)	34/30	1.66 (1.00–2.74)	11/10	1.55 (0.64–3.74)	23/20	1.79 (0.96–3.33)
National security (971)	534/622	1.40 (1.17–1.66)	244/249	1.36 (1.06–1.74)	290/373	1.45 (1.13–1.85)

^aBased on three or more exposed cases. Odds ratios that exclude 1.0 are noted in bold typeface.

amusement and recreation services, the general building contracting industry, line-haul operating railroads, general farms, primarily with crops, and in national security. Among whites, increased ORs were found for those who were ever employed in variety and furniture stores, paper mills, soft drink and carbonated water production, direct-selling establishments, building materials, membership organizations, eating and drinking places, national security and transportation equipment, while risks were decreased for persons working in the miscellaneous machinery industry, motor freight transportation and warehousing, local- and long-distance trucking, and in banking.

When usual industry was analyzed (data not presented), significant associations were found for employment in amusement and recreation services (OR = 3.56; 95% CI =

1.25–10.1) and in masonry, stonework, tile setting, and plastering (OR = 2.67; 95% CI = 1.06–6.72). Among blacks, usual employment in the amusement and recreation industries (OR = 10.8; 95% CI = 1.32–88.1), line-haul railroads (OR = 5.66; 95% CI = 1.22–26.30), and general building contracting (OR = 5.20; 95% CI = 1.08–25.10) showed significantly increased risks. Among whites, usual employment in the masonry, stonework, tile setting, and plastering industry (OR = 9.49; 95% CI = 1.13–80.0) and miscellaneous repair services (OR = 5.11; 95% CI = 1.01–25.80) showed statistically increased risks, while risks were decreased for employment in blast furnaces, steel works, and rolling and finishing mills (OR = 0.37; 95% CI = 0.15–0.95).

Subjects in the railroad transportation industry worked as rail and track laying equipment operators, locomotive

TABLE V. Prostate Cancer Risk^a and Duration of Employment in Industry^b

Industry (SIC)	<5 years		5–19 years		≥20 years		Trend, <i>P</i>
	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	Cases/ controls	OR (95% CI)	
General farms, primarily crop (019)	46/38	1.62 (1.04–2.53)	50/48	1.27 (0.84–1.92)	9/8	1.34 (0.51–3.51)	0.16
Railroad transportation (40)	41/35	1.47 (0.92–2.34)	14/13	1.43 (0.66–3.09)	10/2	6.47 (1.40–29.9)	0.002
				1.31 (0.60–2.86)			
Railroads (401)	39/34	1.43 (0.89–2.30)	13/13		10/2	6.45 (1.40–29.8)	0.003
Railroads, line-haul operating (4011)	38/32	1.48 (0.91–2.40)	13/13	1.30 (0.60–2.86)	9/2	5.85 (1.25–27.4)	0.006
Department stores (531)	25/29	1.29 (0.74–2.23)	12/7	2.54 (0.99–6.57)	10/9	1.39 (0.56–3.46)	0.15
Variety stores (533)	8/2	5.67 (1.19–26.90)	0/0		1/1	1.52 (0.09–24.80)	0.61
Radio, television, and music stores (573)	7/1	9.49 (1.15–78.00)	1/2	0.78 (0.07–8.89)	0/0		0.14
Eating and drinking places (58)	53/52	1.44 (0.96–2.14)	34/25	1.79 (1.05–3.05)	15/15	1.31 (0.63–2.71)	0.16
Eating and drinking places (581)	53/52	1.44 (0.96–2.14)	34/25	1.79 (1.05–3.05)	15/15	1.31 (0.63–2.71)	0.16
Eating places (5812)	50/47	1.51 (1.00–2.29)	23/23	1.30 (0.72–2.35)	11/11	1.30 (0.56–3.05)	0.35
Drinking places (alcoholic beverages) (5813)	7/6	1.48 (0.49–4.50)	11/2	7.12 (1.56–32.50)	4/4	1.25 (0.31–5.06)	0.16
Liquor stores (592)	6/1	8.93 (1.06–75.10)	1/4	0.35 (0.04–3.21)	3/0		0.66
Membership organizations (86)	8/7	1.78 (0.63–4.97)	12/11	1.58 (0.69–3.63)	19/12	2.18 (1.04–4.54)	0.02
Labor unions and similar labor organizations (863)	2/0		2/1	3.83 (0.34–42.60)	5/1	6.05 (0.70–52.50)	0.04
Justice, public order and safety (92)	9/8	1.65 (0.63–4.34)	7/11	0.90 (0.34–2.34)	18/11	2.46 (1.14–5.28)	0.03
National security (971)	428/494	1.41 (1.18–1.70)	85/84	1.62 (1.17–2.25)	21/42	0.81 (0.47–1.40)	0.70

^aBased on five or more exposed cases.^bOdds ratios that exclude 1.0 are noted in bold typeface.

operators, railroad brake, signal, and switch operators, but also mail clerks, waiters, vehicle washers and equipment cleaners. When risks in the railroad industry before and after 1960 (indicating the introduction of diesel engines) were compared, only blacks who started to work on railroads after 1960 had a significantly elevated risk (OR = 3.01; 95% CI = 1.06–8.98).

Duration of Employment in Industries

Odds ratios increased with duration of employment in railroad transportation, particularly line-haul operations ($\chi^2_{\text{trend}}, p = 0.006$), and in membership organizations ($\chi^2_{\text{trend}}, p = 0.02$), labor unions ($\chi^2_{\text{trend}}, p = 0.04$), and justice, public order and safety ($\chi^2_{\text{trend}}, p = 0.03$) (Table V). Elevated risks were largely limited to short-term employment (<5 years) on farms (primarily crop production) and in variety stores, radio, TV and music stores, liquor stores, and in national security. Employment in eating and drinking places showed increased risk with 5–19 years of employment, but risks did not continue to rise for longer-term employment.

DISCUSSION

This and a parallel investigation of cancer mortality [Krstešević et al., 1998] were designed to provide clues about

potential occupational risk factors for prostate cancer. In this study, risk of prostate cancer increased with increasing duration of employment in protective services, particularly for firefighters, and among power plant operators, stock handlers, and brick masons, and in the railroad transportation industry. In our study of cancer mortality [Krstešević, this issue], excesses were also noted among firefighters and stationary engineers, particularly among blacks. In this study, increased risks were also found for barbers, athletes, surveying and mapping technicians, cleaning and building supervisors and janitors, general farmers, packing and filling machine operators, and grader, dozer, and scraper operators, but associations with duration of employment were not seen. Employment in variety stores and in eating and drinking places was also associated with increased risk. Some excess risks were specific to either blacks or whites, but clear patterns to explain the racial differential in risk were not found.

Firefighters, railroad workers, and stationary plant operators may have some exposures in common. Firefighters may be exposed to polycyclic hydrocarbons, such as benzo(a)pyrene, and other products of combustion. Firefighters may also be exposed to polychlorinated dibenzofurans, dibenzo-p-dioxins, formaldehyde, metals (e.g., chromium, cadmium), aromatic amines, various chlorinated hydrocarbons,

and asbestos, at lower levels or on an occasional basis. Railroad transportation workers may be exposed to asbestos and PAHs (benzo(a)pyrene and 1-nitropyrene) from a variety of combustion-related sources, including diesel exhausts. Power plant operators, who were mostly stationary engineers, may be exposed to PAHs (from coal and fuel oil), asbestos, and soot [Demers et al., 1994; Nadon et al., 1995; Aronson et al., 1996].

Our study pointed to an excess risk for men who worked in the railroad industry, particularly among blacks initially employed after 1960 (when diesel power was generally introduced). A Canadian population-based case control study of prostate cancer showed a weak association with employment in the railway transportation industry [Aronson et al., 1996]. Others reported an increased risk for exposure to diesel fuel and PAHs from various sources [Demers et al., 1994; Nadon et al., 1995]. Another study reported a significantly increased risk for prostate cancer among firefighters under the age of 65, although no relation was seen with duration of exposure [Siemiatycki et al., 1987]. In other studies of firefighters [Guidotti et al., 1993; Tornling et al., 1994], risk for prostate cancer was only slightly elevated. Risk for prostate cancer was not previously identified among stationary engineers [Kelsh et al., 1997].

Workers in janitorial services, food and beverage service, and as mechanics and repairers showed some evidence of increased risk in our study; but no obvious common exposures occur among these occupational groups. Another study in the U.S. showed an increased risk for prostate cancer among janitors and workers in building service [Abd Elghany et al., 1990]; however, janitors in the rubber industry showed no excess [Goldsmith et al., 1980]. Possible occupational hazards in eating and drinking places include fumes containing PAHs from tobacco use, wood, soot, or hot oils, but studies of food preparation and processing workers have been both positive [Abd Elghany et al., 1990; Hsing et al., 1994; van der Gulden et al., 1995; Aronson et al., 1996] and negative [Pearce et al., 1987; Coggan and Wield, 1995]. Our finding of excess risk among brick masons and related workers, who are generally exposed to low levels of silica and possibly asbestos, is not supported by the one other study of this occupation [Hall and Rosenman, 1991].

Farming has been associated with a modest increase in risk for prostate cancer of about 40% in several [Blair and Zahm, 1992; Fincham et al., 1992; van der Gulden et al., 1992, 1996; Dosemeci et al., 1994] but not all studies [Ronco et al., 1992; Morrison et al., 1993; Hsing et al., 1994; Wiklund and Dich, 1995], as recently reviewed [Keller-Byrne et al., 1997]. The specific factors determining the excess have not been identified. Our finding of an excess appeared to be restricted to short-term workers in crop, as opposed to livestock, production and increased risk was not limited to those who worked after 1950, when pesticides were generally introduced into agriculture. A study in

Canada implicated the use by farmers of phenoxy herbicides with increased risk of prostate cancers [Morrison et al., 1993], but workers in manufacturing or spraying of these compounds showed no excesses [Bueno de Mesquita et al., 1993; Asp et al., 1994]. Use and manufacture of fertilizers has also been related to prostate cancer in some [Hagmar et al., 1991; Ilic et al., 1996] but not all studies [Goldsmith et al., 1980; Fincham et al., 1992; Morrison et al., 1993; Ewings and Bowie, 1996].

The excess risk identified among athletes, most of whom worked in the amusement, entertainment, and recreation industry, was intriguing because of the potential use of anabolic steroids in this group. However, closer examination of individual job histories revealed that these subjects had been engaged in a variety of sports (e.g., baseball, basketball, football, boxing) and all cases and controls had been athletes several decades ago, usually before 1960, when use of these performance-enhancing drugs began. Athletes, however, may have altered levels of circulating testosterone [Shepard, 1990], and risk of prostate cancer in this group needs to be further evaluated. We also identified an excess risk among barbers, who may be exposed to a number of chemicals, such as aromatic amines and related nitro compounds, formaldehyde, and methacrylate [Skov and Lynge, 1994]. Some studies have shown increased risks for prostate cancer in this industry [Guberman et al., 1985; Gallagher et al., 1989; Hrubec et al., 1992].

There is some evidence that employment in the rubber industry [Kelsh and Sahl, 1991; Nomura and Kolonel, 1991; Ross and Schottenfeld, 1996], nuclear industry [Rooney et al., 1993; van der Gulden et al., 1995; Ewings and Bowie, 1996; Loomis and Wolf, 1996], metal industry [van der Gulden, 1997], and work as an airline pilot [Band et al., 1996] may be linked to increased risk for prostate cancer. We, however, had too few subjects in any of these industries or occupations (except for metal workers) to adequately assess risk. No excess risk was seen among occupations or industries with obvious cadmium exposure (e.g., electroplaters, painters, pigment makers, and producers of steel machinery), which have been linked with prostate cancer in some studies [Hayes, 1997].

In our study, workers in some white-collar occupations showed increased risks for prostate cancer, including officials and administrators, salesmen, sales supervisors and engineers, as well as workers in membership organizations, labor unions, and justice, public order and safety, but no overall pattern of increased prostate cancer risk was identified for workers in high socioeconomic status jobs and those that may be associated with low physical activity [Hayes et al., 1998]. Other investigations have not been consistent with respect to risk among white-collar workers or in relation to socioeconomic status, with both positive and negative findings. Study results concerning the role of

physical activity have also been conflicting [Nomura and Kolonel, 1991; Ross and Schottenfeld, 1996].

Although this was a large case control study of prostate cancer, numbers of subjects were, nevertheless, relatively small for assessment of risk in specific occupations and industries, due to the great variety of jobs held by the U.S. workforce. Further, assessments of risk based only on occupation and industry provide limited insight about specific exposures [Stewart and Stewart, 1994]. The large number of job group comparisons made has also certainly led to some false-positive findings. The study strengths, however, include direct interviews with all study subjects and the ascertainment of complete occupational histories, as occupational data provided by surrogate respondents is generally incomplete and substantially less accurate [Hennenberger, 1996].

This large population-based study of incident prostate cancer and a parallel study of prostate cancer mortality [Krstev et al., 1998] did not identify occupational risk factors that could account for a substantial proportion of prostate cancer in the U.S., but did provide some clues about potential occupational risks; in particular, the excess risks observed among railroad workers, firefighters, and power plant operators (with potential common exposure to PAHs) deserve further attention.

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